AIRS Level 1C Radiance Development

Scott Hannon, Larrabee Strow, Sergio DeSouza-Machado

Atmospheric Spectroscopy Laboratory (ASL)
Physics Department
and the
Joint Center for Earth Systems Technology

University of Maryland Baltimore County (UMBC)

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Introduction

- AIRS L1b is meeting requirements for knowledge of SRF centroid (1% of SRF width, or 8 ppm, but just barely over 5 years.).
- AIRS radiometric stability is far better than its frequency stability in terms of radiances
- AIRS L1b frequencies can be measured to better than 1 ppm
- AIRS L1b radiances should be available on a fixed frequency scale for climate applications (correcting for SRF centroid drift)
- We would call the above product, a L1c radiance

Limitations of Existing L1b Radiances

1. Dead/bad channels
2. Noisy/popping channels
3. Spectral gaps
4. Frequency drift

Mitigating the above limitations with a L1c product may help users. Corrections for spectral drift will be improved if items #1-3 are first fixed.

- Simple algorithm may allow semi-accurate filling of dead/bad and noisy/popping channels (H. Aumann/JPL is working on this.)
- Channels with estimated radiances will be flagged, and only used for non-sensitive applications.

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"Gap" Channels

Needed for Frequency Interpolation, etc.

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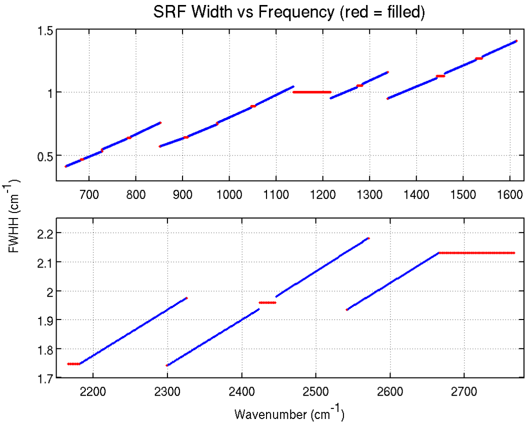

- V6 AIRS RTA currently under construction
- Includes 456 "gap" channels with IDs 2379 to 2834
- "Gap" channels fill spectral gaps, extend some modules, and allow interpolation of channels at ends of modules.

Frequency Drift

- AIRS frequency drift has been characterized several ways:
  - Cross-correlate either clear FOVs or cloud-cleared FORs with radiances computed from either ECMWF or AIRS L2 Supplemental profiles. Generally use modules M10, M11, and M12 (long wave)
    - Using granule averages (UMBC, Gaiser)
    - Using mean radiances binned by latitude and month (UMBC)
  - Comparing to on-board parylene (S. Gaiser, JPL)
- Frequency drift has several components:
  - Slow long-term drift
  - Seasonal variation (solar beta angle)
  - Faster orbital variation (solar forcing). $\Delta\nu$ variation with latitude often used as a proxy for variation with orbital position/time
  - One-time offset due to Nov. 2003 Aqua shutdown

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Frequency Variations; (Latitude = Orbital Time)

Three time scales (years, months, minutes), all same magnitude

Note: Nov. 2003 $\Delta\nu$ is significant

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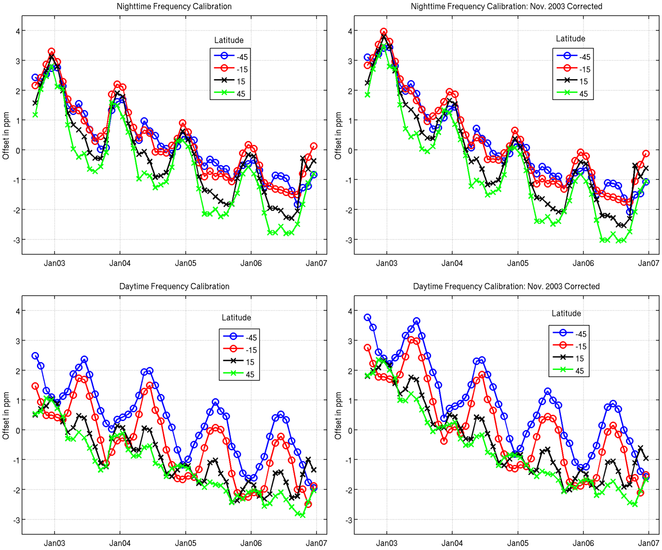

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Fringe and $\Delta\nu$ Shifts from Nov 2003 Shutdown

Both effects are signficant, only fringe shifts shown in graph.

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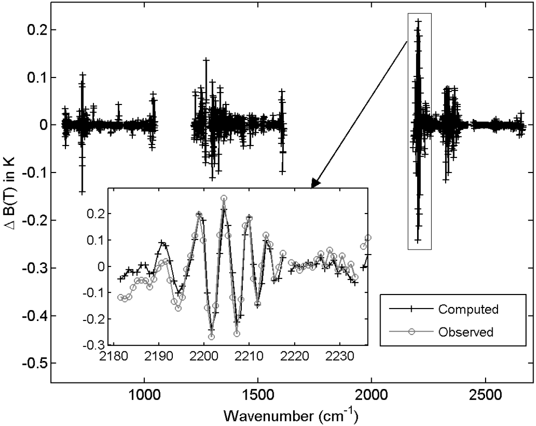
$\Delta\nu$ shifts due to shutdown will be included in frequency calibration model. We *might* try to correct pre-Nov. 2003 radiances to for fringe shifts and make them look like post-Nov. 2003 radiances. This will probably be an off-line algorithm.

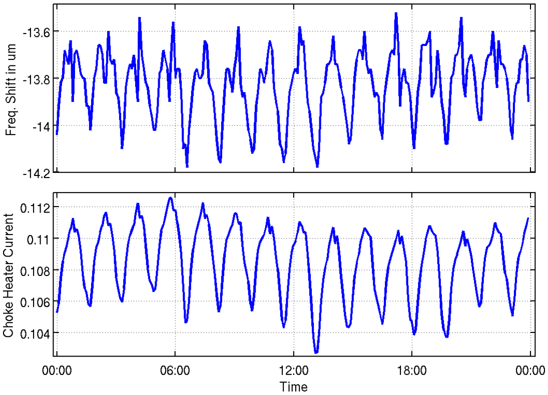


Frequency Drift Measurement and Parameterization

- Use measured radiances, cross-correlated with computed radiances as the truth, hopefully on a per granule basis. (Offline calculations.)
- Previous freq. cal. slide used monthly/latitude binned data with limited higher latitude observations.
- Re-run granule averaged frequency cal. over some sampling of complete AIRS record via cross-correlation of CC'd FORs with simulated radiances. (Offline truth.)
- Parameterize results with appropriate terms:
  - Long-term drift: Quadratic term from offline calculations
  - Solar beta angle (seasonal): use actual computed solar beta angle, or smoothed scan head temperature, or empirical fourier series approximation, or some combination
  - Orbital variations: Choke heater current (or scan head temperature), or empirical fourier series approximation
- Test parameterization on data not included in previous offline characterization.

Fast Orbital Frequency Variations

Cross-correlation of CC'd radiances using L2 Supp profiles, versus choke heater current



- Retrieved drift for 2005/09/26 from L2 CC granule data
- Forward calculations used L2 support profiles
- Noise in retrieved drift typically larger near poles
- Note correlation of drift with heater current

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Seasonal Variations (Solar β Angle) with Scan Head Temp (low pass filtered) for Comparison

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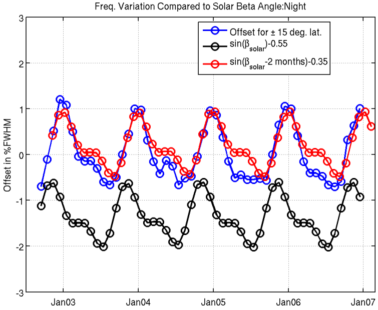

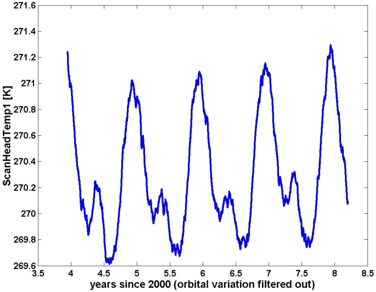

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Slow Frequency Drift

Note: *rate of drift* is shown

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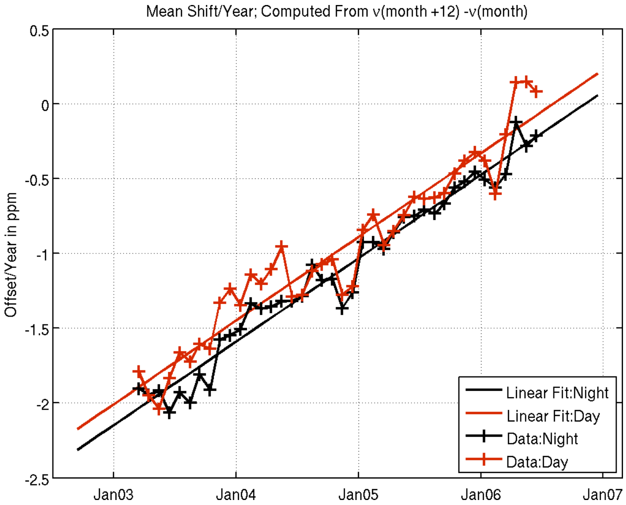

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Calculated B(T) Changes over 4-years

Slow Drift Term Only

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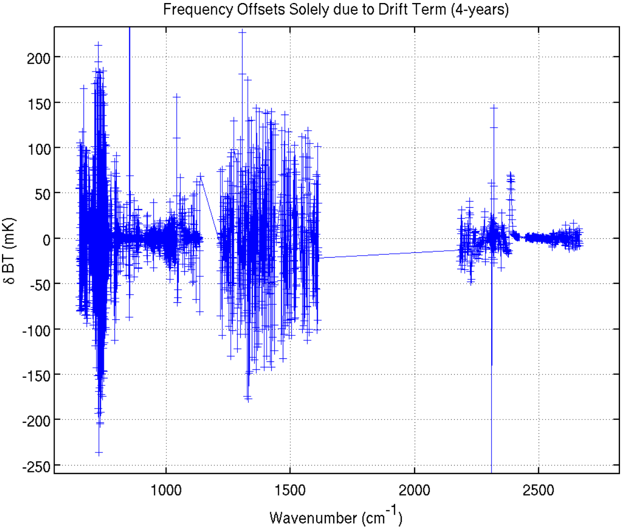
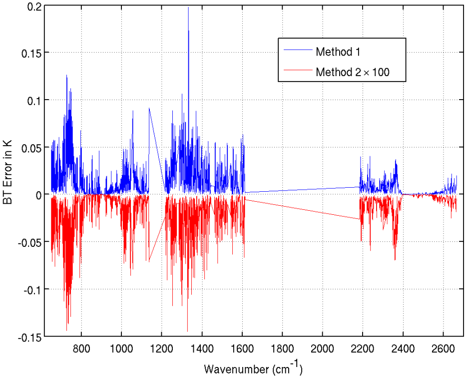


L1C Product: Shift Radiance to Fixed ν Grid

- If the true frequency of AIRS data is known, we can apply an adjustment to the observed radiances to estimate what their value would be at some fixed frequency.
- We are considering two methods to shift the radiance
- Method 1: interpolate the measured radiances (augmented by fake radiances for dead/bad/noisy channels). Preliminary testing shows noise does not have much impact on the quality of this interpolation.
- Method 2: calculate simulated radiances at two slightly offset fixed frequency sets, and use these to estimate the change in radiance due to the frequency drift, and add this to the observed radiance.

Considerations for Method 1

RMS Errors shown for both methods in graph below for 5 ppm shift.



- Errors relatively large for Method 1
- Requires filling dead/bad/noisy channels with estimated radiance
- But, if the above is available, calculation is simple

Considerations for Method 2

- Requires a simulated radiance calculation, which requires an estimate of the atmospheric state, including clouds. The simulated radiances does not need to be an exact match to the observed, but it must be a fair approximation.
- Requires AIRS RTAs at two slightly offset frequencies. Furthermore, the two RTAs must be well behaved in the sense that differences in the radiance are primarily due to the frequency offset rather than unrelated modeling errors.
- If the above requirements can be met (which is uncertain), then the interpolation can be done accurately over a larger distance than Method 1.
- Multiple RTAs are currently under construction for V6 so Method 2 remains a possibility.

Summary and Plans

- A new L1C radiance product is in development for V6.
- L1C radiance will have more stable frequency and more complete spectral coverage than L1B. It could be stored, or computed from an algorithm given to the DAAC or to users.
- Currently no definite plan for the L1C product format and how/whether it fits into the PGE and DAAC processing.
- Multiple AIRS RTAs under construction for V6 with filled channels and different frequencies.
- Once the new RTAs are done (May?), we will start work on L1C.
- UMBC plans to focus on measuring frequency drift
- JPL plans to focus on filling radiances
- Currently no schedule for V6, but should know more by the next AIRS meeting.